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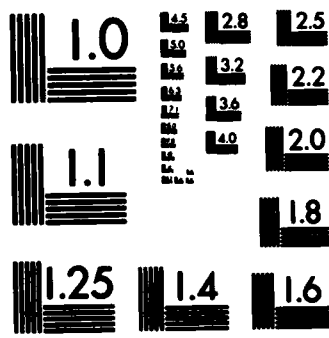
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LETTER REPORT

REMOTELY OPERATED AUTOMATIC CANNON FOR ARMORED VEHICLES (U)

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I. INTRODUCTION

1. This letter report surveys automatic-gun overhead turrets designed and produced in various countries. Several European firms produce armored-vehicle automatic gun turrets with the weapon mounted externally overhead. This turret location offers three significant advantages:

- Greater protection for vehicle and personnel when the gun is fired from the hull defilade position
- Reduced vehicle vulnerability due to a smaller frontal silhouette and a smaller armored volume, thereby permitting a corresponding reduction in turret weight and subsequent greater power-to-weight ratios or more armor protection.
- Reduced design constraints, permitting larger weapons and greater versatility i.e., greater angles of elevation and depression, use of secondary armament, employment of night vision devices, etc.

The turrets presently available are easily adaptable with a minimum of modification to light armored vehicles, which include vehicles in the US inventory, the M113 armored personnel carrier, LVPT-7 amphibious assault vehicle, or the Piranha LAV (light armored vehicle). This turret configuration will gain rapid acceptance and development as countries recognize the need for a low-cost alternative to the current infantry fighting vehicles (IFV), i.e., the US M2, the West German Marder, and the British MCV-80. A vehicle such as the Italian VCC-2, with applique armor and mounting a 25- or 30-mm gun, will meet the requirements of protection, firepower, and improved reliability, availability, maintainability, and durability (RAM-D). Physical and operational characteristics of five representative automatic cannon turrets are summarized in the table at the end of this report.

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## II. BASIC CONCEPTS

1. The overhead remotely operated weapon offers significant advantages over the conventionally configured turret, a fact that has been generally recognized and will strongly influence future tank concepts. The overhead gun technology is readily available for light armored vehicles, having already been adopted by some armies. Because the ease of adaptation and minimal vehicle modifications required, these turrets are particularly attractive for arming or up-gunning light armored vehicles.

2. Remotely operated weapon stations for armored vehicles have gained acceptance with foreign armies, although their applications have varied. In Britain and France, the tank commander's machinegun has been configured to be remotely operated, to minimize the size of the cupola while retaining reasonable elevation limits and maintaining the nuclear-biological-chemical (NBC) integrity of the vehicle by allowing the commander to operate in the closed-hatch mode. Several European firms produce overhead turrets for automatic cannons (from 20 to 35 mm) that have been adopted for LAV, the most notable of these are the West German Marder, the French AMX-10 P and VAB, and the Netherlands "Lynx" command and reconnaissance vehicle. Several European firms and governments have undertaken the development of large-caliber overhead guns, the most well known being the UDES-20XX tank destroyer. The deployment of armored vehicles with large-caliber remotely-operated guns will not begin before the latter half of the 1980s, the delay being attributed to the need to develop automatic loaders, ammunition compatible with automatic loaders, remote observation and fire-control devices, and suitable chassis.

3. Externally mounted cannons offer several significant advantages and a few relatively minor disadvantages, as compared to conventionally configured turrets. Advantages and disadvantages are as follows:

- Advantages:

- Smaller turret-ring diameter

- Greater elevation and depression limits

- Reduced chemical-biological-radiological (CBR) and ventilation requirements

- Decreased vulnerability of the crew

- Reduced weapon side effects for crew (i.e., muzzle flash noise, and fumes)

- Reduced moments of inertia, enabling smaller turret drive and stabilization systems to be used

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--In two-man turrets, close proximity of crewmembers and less-cluttered crew compartments, permitting common controls and improved crew communications, command, and control

--Ability to perform some maintenance from outside the vehicle

● Disadvantages:

--Higher overall vehicle silhouette

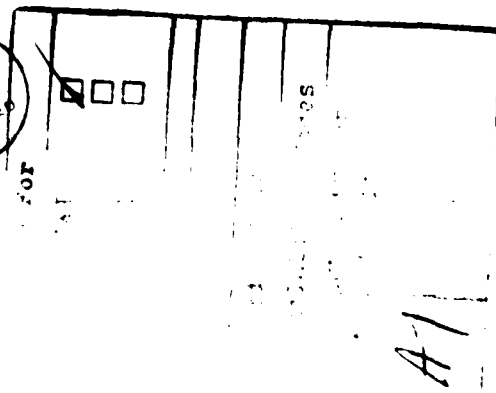
--Panoramic field of view partially obstructed by the weapon mast

--Requirements to load weapons that are not belt fed from outside the vehicle

--Slightly greater parallax error

--More complicated redundancy features on controls and ammunition feed-system

4. The overriding considerations are the vehicle configuration and the vulnerability of the crew. The overhead gun places the armament outside the armored envelope, permitting a smaller comparable internal volume for the turret, a reduction in the armor weight, and a smaller turret ring, enabling the crew to be located lower in the hull. The flexibility of a design involving "externally hung" weapons is demonstrated by the large angles of elevation and depression and the ability to mount secondary items, such as searchlights, thermal pointers, and coaxial machineguns on the weapon mast. These considerations are most vividly demonstrated in its Marder A1A turret, which will mount a 25-mm dual-feed cannon in a two-man turret in a space initially intended for a 20-mm gun in a one-man conventional turret. Another significant advantage of the overhead cannon is the placement of the turret crew lower in the hull, thereby making them less vulnerable. While the overhead gun design increases the total vehicle height and weapon vulnerability, it generally affords greater protection to the crew relocated lower in the hull. The increase in protection is, of course, relative to the height of its vehicle hull. Shallow hulls require the truncated turret to protrude further from the hull roof to accommodate the crew seated in the upright position. The overhead gun is most effective when it fires while the vehicle is in the hull defilade position; in this case, neither crew nor the vehicle need be exposed to direct enemy fire.



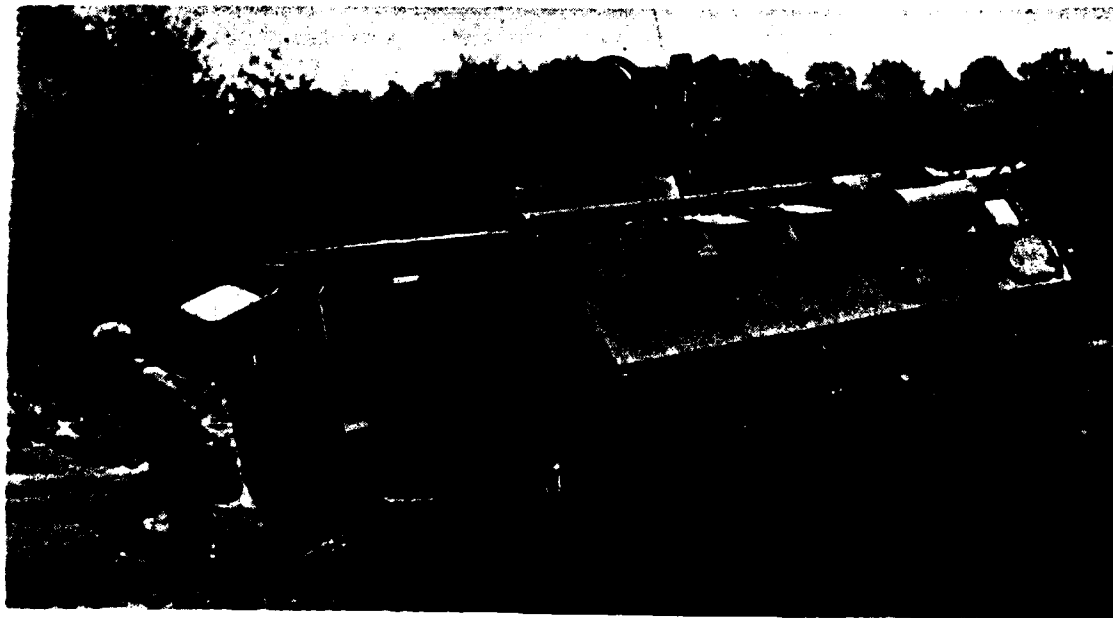
### III. FIELDDED SYSTEMS

Several European firms are actively designing, producing and marketing overhead turrets for automatic cannons. These firms include the French Groupement de Industries de Armements Terrestres (GIAT), the West German Keller and Knappich, Augsburg (KUKA) organization, and the Swiss Oerlikon firm.

#### A. FRENCH CONCEPTS AND GIAT PRODUCTS

1. In general, the French have pursued a policy of developing a family of basic vehicle variants to fill the variety of roles within a particular unit; current examples are the AMX-10 and the VAB. The advantages of this approach are obvious--reduced initial costs (developmental and manufacturing) and reduced operational costs--(training, maintenance, and spare parts). The overhead gun is ideally suited for this approach because the low internal volume permits greater design flexibility and a minimum of modifications to the basic vehicle.

2. GIAT produces two turrets, a one-man version (Toucan I) and a two-man version (Toucan II); both have several variants. The Toucan I turret is mounted on the following French Army vehicles: AMX-10 ECH (repair vehicle), AMX-10 TM (mortar tractor), VAB-VCI (infantry combat vehicle) (fig 1), and AMX-VCI. It also can be mounted on the Panhard M3 and VCR/TT for foreign military sales.



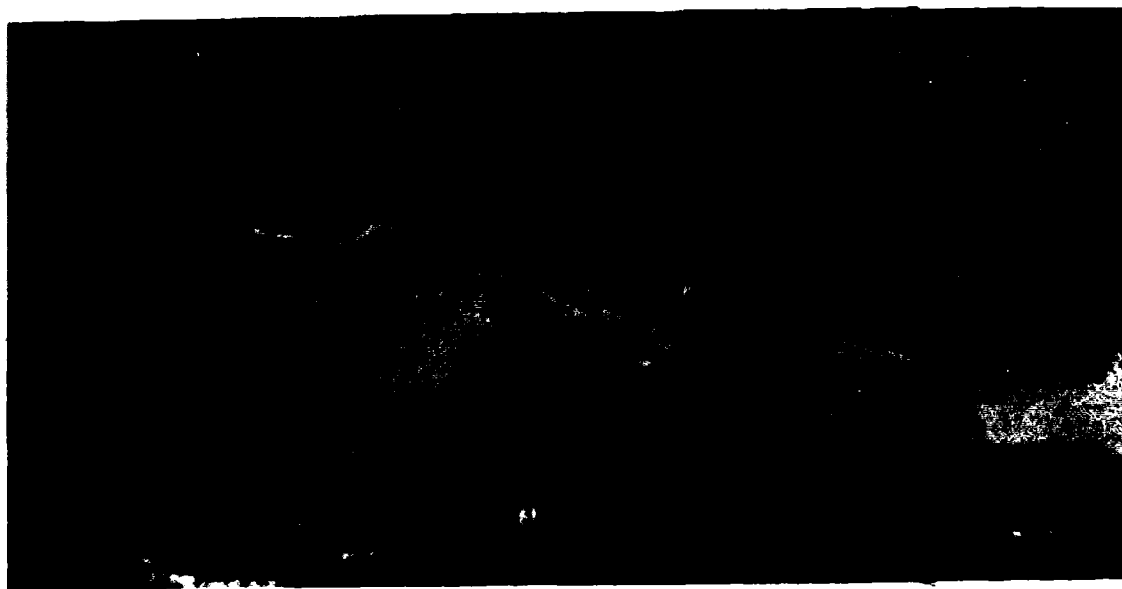
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Figure 1. VAB-VCI Infantry Combat Vehicle

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3. The Toucan I has two distinct variants. The first is a lightweight aluminum-bodied variant that mounts either the M621 gun or the HS 804 cannon. This turret was designed for an extremely light chassis. The second variant, a steel-bodied turret, weighs approximately 100 kg more than the aluminum version, and its main armament can be the M621 gun or the HS 804 or the more powerful M693, HS 820, or Rh 202 cannon.\* The cannons mounted in the Toucan I have either dual- or single-feed systems. The magazines are located externally, with 96 rounds stored in the single-feed system and 45 armor-piercing (AP) and 75 high-explosive (HE) rounds stored in the dual-feed magazines. In addition to the characteristics described in the table at the end of this report, optional equipment for the turrets includes searchlights, electric turret-drive systems, four 80-mm smoke grenade launchers, single or dual 89-mm recoilless rifles, and a coaxial 7.62-mm machinegun fed from an external 200-rd ammunition box.

4. The Toucan II turret was designed for use on the AMX-10 P IFV (fig 2). At a considerable cost in weight and size, this turret places both the gunner (left) and commander (right) in the turret, significantly improving the commander's observation capability over that available with the Toucan I. Toucan II can mount a large variety of main armaments basically similar to those available for the Toucan I. The AMX-10 P light armored vehicle with the Toucan I turret mounts a dual-feed 20-mm M693 gun. The ammunition for both the main gun and coaxial machinegun is fed from ammunition boxes located within the turret basket, which hold 260 HE and 65 AP 20-mm rounds and 200 rounds of 7.62-mm ammunition. The turret drives are electric with manual backup.



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Figure 2. AMX-10 P Infantry Fighting Vehicle

\*GIAT has shown interest in the Hughes 25-mm chain gun, and this will be a future option.

B. KELLER AND KNAPPICH (KUKA)

5. Although the West German KUKA firm manufactures a variety of automatic cannon mounts and armored turrets, its most widely recognized product is the Marder turret, of which approximately 2000 have been produced. KUKA also manufactures turret bodies for Oerlikon; these mount the Oerlikon weapon systems and are better known under the Oerlikon name.

6. The Marder (fig 3) was first fielded in 1970 and is the forerunner of the current generation of overhead automatic cannon mounts. The ongoing Marder 1A product-improvement program will involve upgrading the fire-control and weapon systems. The original prototype configuration of the Marder located the vehicle commander in the left front side and the one-man (gunner) turret centrally in the hull. In 1966, the commander was relocated in the turret to improve his ability to observe and direct fire. Space limitations necessitated the current side-by-side location of the commander and gunner, with the weapon mounted externally overhead.

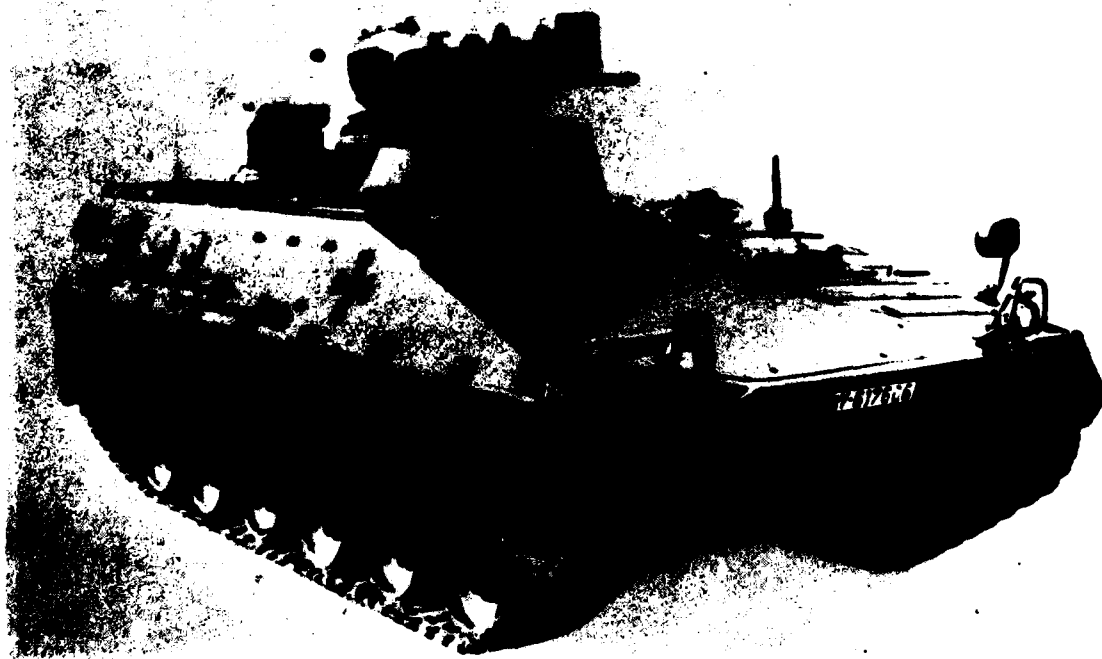


Figure 3. West German Marder Infantry Fighting Vehicle



7. In the Marder, the West Germans have continued to emphasize observation and fire-control systems. The gunner and commander have identical PERI Z-11 periscopic sights. The PERI Z-11 has a unity window and a 2X or 6X telescopic sight with both a ground and antiaircraft reticle. The prismatic heads are fixed in azimuth and are elevated with the weapon by a parallelogram linkage. The commander has eight unity periscopes providing panoramic vision except for a 41° arc over the left rear of the vehicle which is blocked by the weapons mast; the gunner has three unity periscopes for observation over the left side. Night vision is provided for the gunner by an active infrared (IR) periscopic sight which replaces his PERI Z-11; the IR/white searchlight is mounted on the same shaft as the gun trunnion.

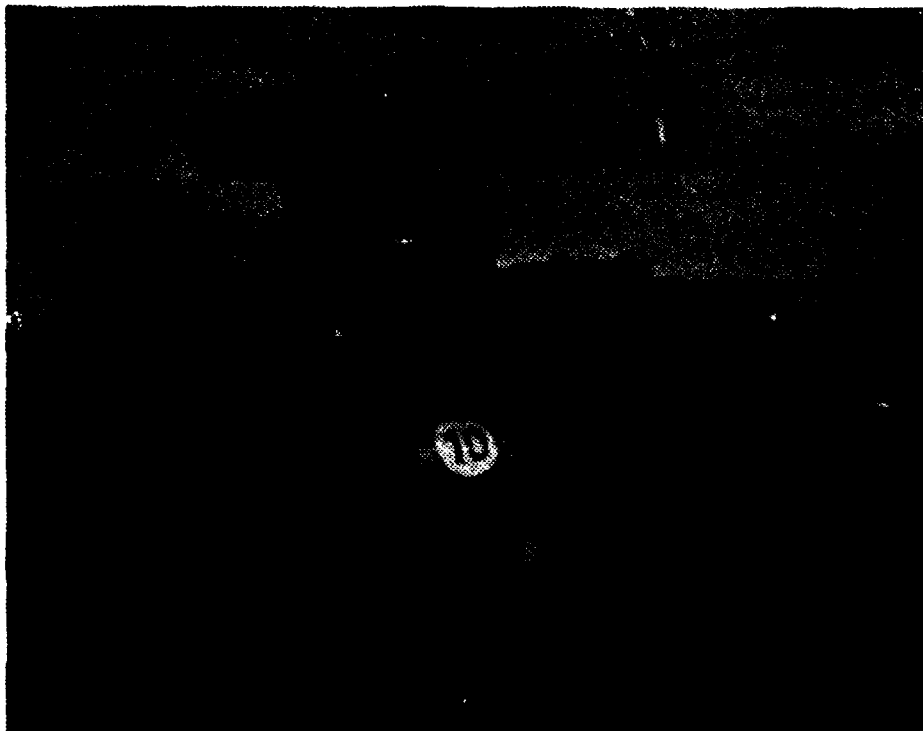
8. The gas-operated 20-mm Rh 202 gun and the 7.62-mm MG3 gun are hydraulically charged and electrically fired. In an emergency, the weapons can be charged by an hydraulic hand pump and fired using foot pedals. The ammunition magazines are located inside the turret, and ammunition is fed to the weapons through a chute in the mast, assisted by an electrically operated conveyor. Although the weapons are gas-operated, the electric conveyor improves weapon reliability by relieving the strain on the ammunition belts and the weapon feed systems. If the ammunition belt is exhausted, both weapons can be charged from inside the vehicle.

9. An improved Marder 1A turret will include the following modifications:

- Upgunning with the 25-mm Mauser Model E
- Providing dual ammunition feed
- Supplying a low-resolution thermal pointer (target indicator)
- Refitting a gunner's passive night sight

#### C. OERLIKON

10. The Swiss Oerlikon Military Products firm markets a family of turrets having the cannon mounted overhead. Although, as previously mentioned, the turrets bodies are produced by KUKA, they are marketed under the Oerlikon logo. Oerlikon is primarily interested in creating a market for their basic weapon systems and ammunition, and is content to allow other firms to design and manufacture the major subsystems. The company has been aggressive in marketing, and many prototype vehicles have been displayed with an Oerlikon turret, but its turret has currently been adopted only in the Netherlands. The Netherlands replaced the .50-caliber machinegun cupola with the GAD-A05 25-mm gun turret for their "Lynx" command and reconnaissance vehicle (fig 4). The two representative turrets discussed here are the 25-mm gun turret GBD-COA and the 35-mm gun turret GDD-A.



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Figure 4. Netherlands "Lynx" Command and Reconnaissance Vehicle

11. The GBD-COA, shown mounted on the Mowag Piranha (fig 5), is a variant of the GAD-A05 one-man turret mounted on the "Lynx." The main armament is the 25-mm dual-fed KBA-B02 cannon. The KBA cannon is the product of a joint effort of TRW (formerly Thompson-Ramo-Wooldridge) and Oerlikon as part of the US Army's Bushmaster program of the 1960s and represents an improvement over the HS 804/820 design family. The recoil-operated ammunition-feed system draws ammunition from the magazines in the turret basket through chutes in the weapon mast. The magazines hold 120 and 80 rounds of high-explosive incendiary (HEI) and armor-piercing discarding-sabot (APDS) ammunition respectively. The turret body is cast aluminum, but other variants of this turret are steel. The turret drive systems are electrohydraulic with a hydraulic hand pump as backup. Less-sophisticated variants have mechanical drive. The gunner gains panoramic observation (except for a 50° arc obscured by the weapon mount) through six vision blocks. The periscopic sight has a 2X or 6X power day channel and a 6-power image-intensification channel.

12. The GDD-A turret was developed by Oerlikon primarily as an alternative for upgunning the Marder (fig 6). The two-man GDD-A turret mounts the 35-mm KDE lightweight cannon in essentially the amount of space as the Marder's original one-man 20-mm gun turret.

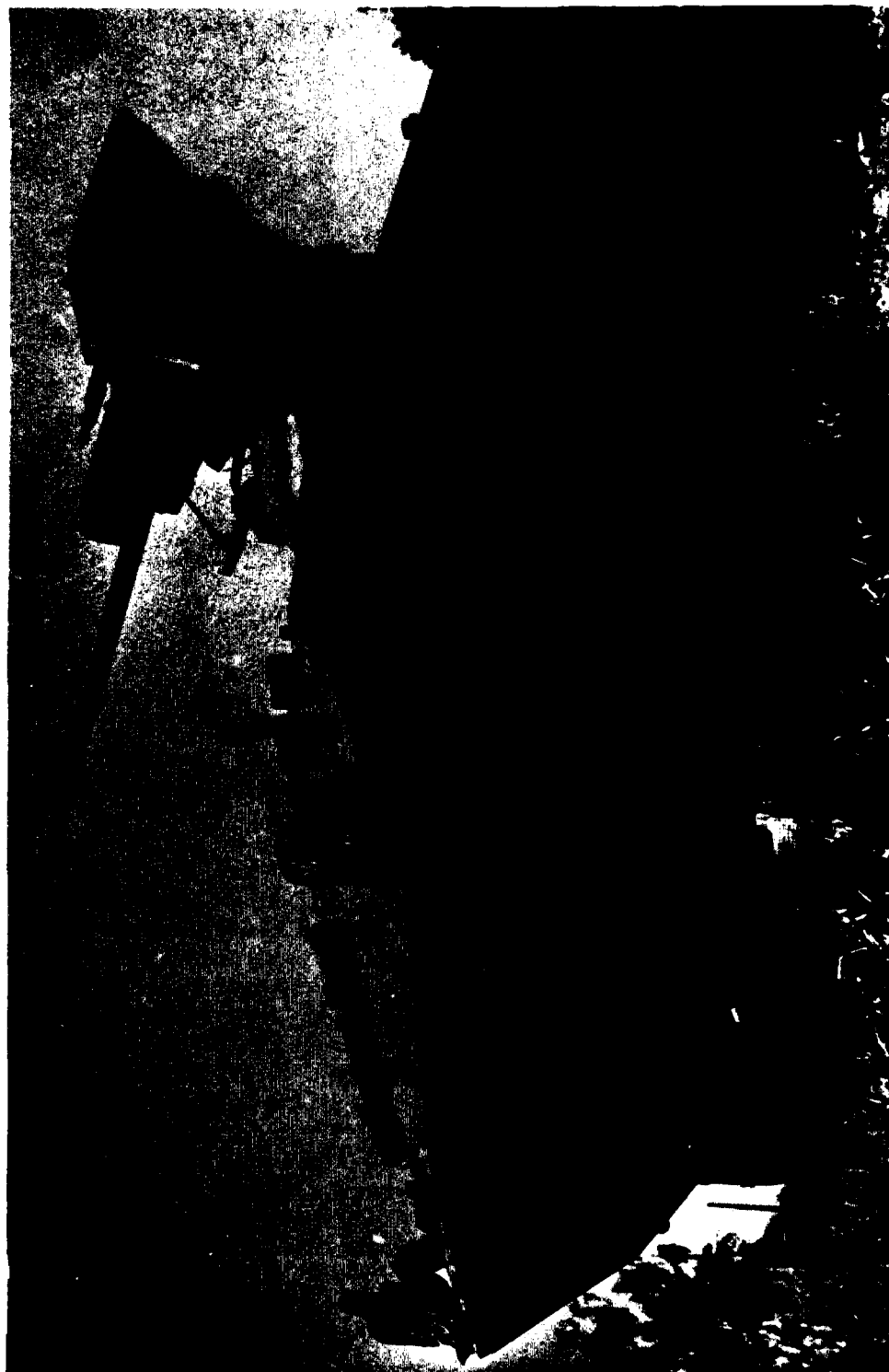


Figure 5. Swiss Mowag Piranha Armored Vehicle

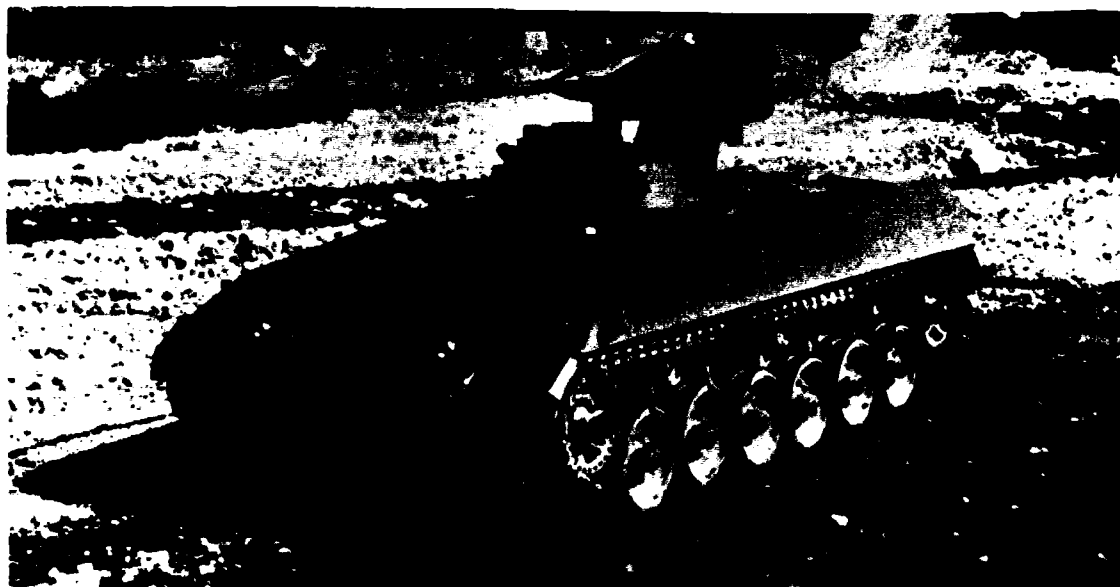


Figure 6. Marder With GDD-A Turret

a. The turret is very similar in appearance and layout to the Marder turret and therefore is probably the result of a joint effort by KUKA (for the turret) and Oerlikon (for the weapon system). This turret has been displayed on several prototype chassis. Although no country has yet adapted this turret for any armored vehicles, it is noteworthy because it demonstrates the potential and limitations of this configuration.

b. The KDE is a lightweight cannon that is ballistically identical to the 35-mm KDA antiaircraft cannon. The cyclic rate of fire has been reduced to 200 rd/min to conserve the ammunition and keep the recoil forces compatible with a light armored vehicle. Two recoil-operated magazines, located externally on either side behind the gun holds 50 rounds of unbelted ammunition each. The gunner can select ammunition from either magazine. The electrohydraulic turret drives are stabilized.

c. The GDD-A turret is probably indicative of light armored vehicle turrets of the late 1980s and early 1990s if the state-of-the-art in armor continues to improve steadily and if most countries replace their 20- and 25-mm cannon. The large internal space required for a 30- or 35-mm cannon (and magazines) would be prohibitive, and if the larger weapons are adopted, externally mounted weapons and magazines would have to be used.

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## Physical and Operation Characteristics of Automatic Cannon Turrets

	TOUCAN I (GIAT)	TOUCAN II (GIAT)	Marder (KUKA)	GAD-COA (Oerlikon)	GDD-A (Oerlikon)
Number of crew	1	2	2	1	2
Turret mass (kg)	698 (steel) 598 (aluminum)	1170	2329	1220	2920
Turret ring dia (mm)	830	1330	1270	970	1270
Cupola height (mm)	180	190	355	510	390
Trunnion height (mm) Above hull roof	480	460	700	661	930
Turret basket dia (mm)	852	1110	1185	1000	1270
Turret basket depth (mm)	1303	1290	1038	1292	1048
Main armament	• 20-mm M621 • 20-mm M693	• 20-mm M693	• 20-mm Rh 202	• 25-mm KBA-B	• 35-mm KDE
Magazines					
Type	External	External	Internal	Internal	External
No. of rounds	96 HE & AP (single feed) 75 HE & 45 AP (dual feed)	55 AP & 260 HE (dual feed)	417 AP & HE (single feed)	80 APDS & 120 HEI (dual feed)	2X50 APDS & HE
Optical & fire control devices	• 1-APX M448, 1X, 6X periscopic sight • 1- 1X reflex AA sight • 6 unity periscopes	• 1-M406 6X periscopic sight (gunner) • 1-OB-40 6X-day/ 5X active IR sight • 1-M371 1X, 6X periscopic/AA sight (commander) • 7 unity periscopes	• 2- PERI Z-11 2X, 6X periscopic sight • 8 unity periscopes (commander) • 3 unity periscopes (gunner) • 6X IR sight	• 1-Philips UA 9124 2X, 6X periscopic sight • 6 unity periscopes	• 2-PERI Z-11 2X, 6X periscopic sight • 8 unity periscopes (commander) • 2 unity periscopes (gunner)
Elevation mechanism					
Type	Manual	Electrical	Electrohydraulic	Electrohydraulic	Stabilized electrohydraulic
Limits	-13 to 50	-8 to 50	-17 to 65	-12 to 52	-15 to 45
Max rate °/s	16	30	50	45	60
Traversing mechanism					
Type	Manual	Electrical	Electrohydraulic	Electrohydraulic	Stabilized electrohydraulic
Max rate °/s	12	50	40	75	90
Optional equipment	• ELEC DRIVES • IR/white searchlight • Day/IR night sight • 4X80 mm smoke grenade launchers • Coaxial 7.62-mm machinegun • 89 mm recoilless rifles	• 4X80 mm smoke grenade launcher • OB-37 i <sup>2</sup> periscopic sight • IR/white searchlight	• PERI Z16 i <sup>2</sup> sight (gunner) • Thermal pointer • Dual feed • Mauser Model E 25-mm cannon	• IR/white searchlight • Smoke grenade launchers • Coaxial 7.62-mm machinegun	• 6X IR periscopic sight • 6 smoke grenade launchers • 6 fragmentation grenade launchers • 7.62-mm coaxial machinegun • IR/white searchlight

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